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COMPARISON OF AVIFAUNAL ASSEMBLAGE AND THEIR ASSOCIATION WITH PLANT COVER IN PROTECTED AND UNPROTECTED MONTANE GRASSLAND ECOSYSTEMS IN BALE MOUNTAINS NATIONAL PARK, ETHIOPIA

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ABSTRACT: Study on the comparison of avifaunal assemblage in the protected and unprotected montane grassland ecosystems of the Bale Mountains National Park was conducted during the wet and dry seasons of 2011–12. Sampling sites based on disturbance were randomly identified and a transect line of one or less than one km was taken. Unprotected habitats had high species richness and diversity during both seasons. However, during the wet season, although the protected habitat had low species richness, it had high species diversity. The abundance of birds between habitats showed significant difference (X^2= 360.06, df= 1 and P < 0.001) during both seasons. During the wet season, avian species richness was negatively correlated with grass height (r= -0.836). The difference in birds' community between the two land use types is likely due to the difference in vegetation structural components. This, in turn, might be due to differences in the level of human-induced factors in the sites, which is higher in unprotected area and of habitat structural diversity (both horizontal and vertical). Future research should focus on comparing guilds (*e.g.,* habitat, feeding and substrate use guilds) in order to better understand the effect of disturbance on birds in the area.

Key words/phrases: Avifauna, Bale Mountains, disturbance, significance, species diversity

INTRODUCTION

Ethiopia is a country with a wide range of climatic, geographical and topographic features. These have contributed to the richness in biodiversity and endemism (Yalden and Largen, 1992; Jacobs and Schloeder, 2001). There are 918 bird species listed for Ethiopia with 20 endemics and 19 globally threatened (Lepage, 2011). From the recorded bird species, 224 are seasonal migrants, 176 Palearctic and 31 species are global conservation concern (BirdLife International, 2001; Ash and Atkins, 2009). In order to conserve birds of the country, 69 Important Bird Areas (IBAs) have been identified (EWNHS, 2001; OARDB, 2007). However, the population of Ethiopia is growing at a rate of 3.1% per year (EWNHS, 1996), leading to increased degree of reliance on the natural resources for different livelihood purposes (Gill, 1995; Anonymous, 2009; Ash and Atkins, 2009). Consequently, biodiversity degradation in the country has been occurring at unprecedented rate (EWNHS, 2001; OARDB, 2007). Thus understanding the effects of, and underlying mechanisms of, disturbances on biodiversity is of paramount importance to develop and implement appropriate mitigation measures.

In this study we present results of a study conducted on the influence of human-induced disturbances on montane grassland birds in the northern Bale Mountains, Ethiopia, by comparing bird assemblages in protected and unprotected areas. The Bale Mountains region is part of the Conservation International's Eastern Afromontane hotspot biodiversity area (Williams *et al*., 2004) and contains the largest Afroalpine habitat in Africa (Hillman, 1986). In addition to its large size and separation from the rest of the Ethiopian highlands, the prevalent rain (eight months per year), varying topography, and diverse habitats in the Bale Mountains have resulted to high levels of species richness and endemism spanning a range of taxonomic groups, contributing to the overall biological importance of the region from both an ecological and evolutionary perspective (Yalden, 1983; Williams *et al*., 2004; Addisu Asefa, 2011).

Despite its immense importance as a centre of endemism and evolutionary processes, this region is currently under conservation threat (Hillman, 1986; Stephens *et al*., 2001; OARDB, 2007;

Eyob Teshome *et al.*, 2011). Agricultural expansion, livestock grazing, unregulated burning, logging for timber production and settlement expansion are increasing in the area at an unprecedented rate (OARDB, 2007). These human activities could pose severe threats to the survival of wildlife and the ecosystem of the region. The main aims of this study were therefore to (1) compare bird species richness and diversity, (2) determine habitat structural composition differences, and (3) examine relationships between bird richness and habitat variables in protected and unprotected grasslands.

MATERIALS AND METHODS

Study area description

Bale Mountains National Park (BMNP) is located at the southeast part of the Ethiopian plateau, about 400 km southeast of Addis Ababa. It has 2,200 km^2 area coverage and lies between 6° 29′–7° 10′ N and 39° 28′–39° 57′ E (Fig. 1). It covers an altitudinal range from 1,500–4,377 masl and has the largest Afroalpine area in the mainland Africa (Hillman, 1986; EWNHS, 1996; Fishpoll and Evans, 2001; Marino, 2003; Ash and Atkins, 2009). The Bale Mountains area is characterized by eight months (March-October) of rainy season and four months of dry season (Hillman, 1986). It experiences temperature extremes, particularly in areas of the highest altitudes during the dry season. The data recorded for 2001–2011 showed that, the temperature of the Park ranges between 1.4°C and 19°C. In terms of fauna, BMNP is a centre of diversity and endemism with a number of threatened Ethiopian endemics (Hillman, 1986).

There are 278 of bird species, including six Ethiopian endemics and many other threatened birds, known to occur in the Park (Addisu Asefa, 2007), representing 20% of the species for Ethiopia. Among the endemic birds of Ethiopia, 57% are recorded in the Bale Mountains (Hillman, 1986; OARDB, 2007). In addition, it is an important over-wintering ground for migrants from Eurasia, particularly passerines and waterfowls (OARDB, 2007).

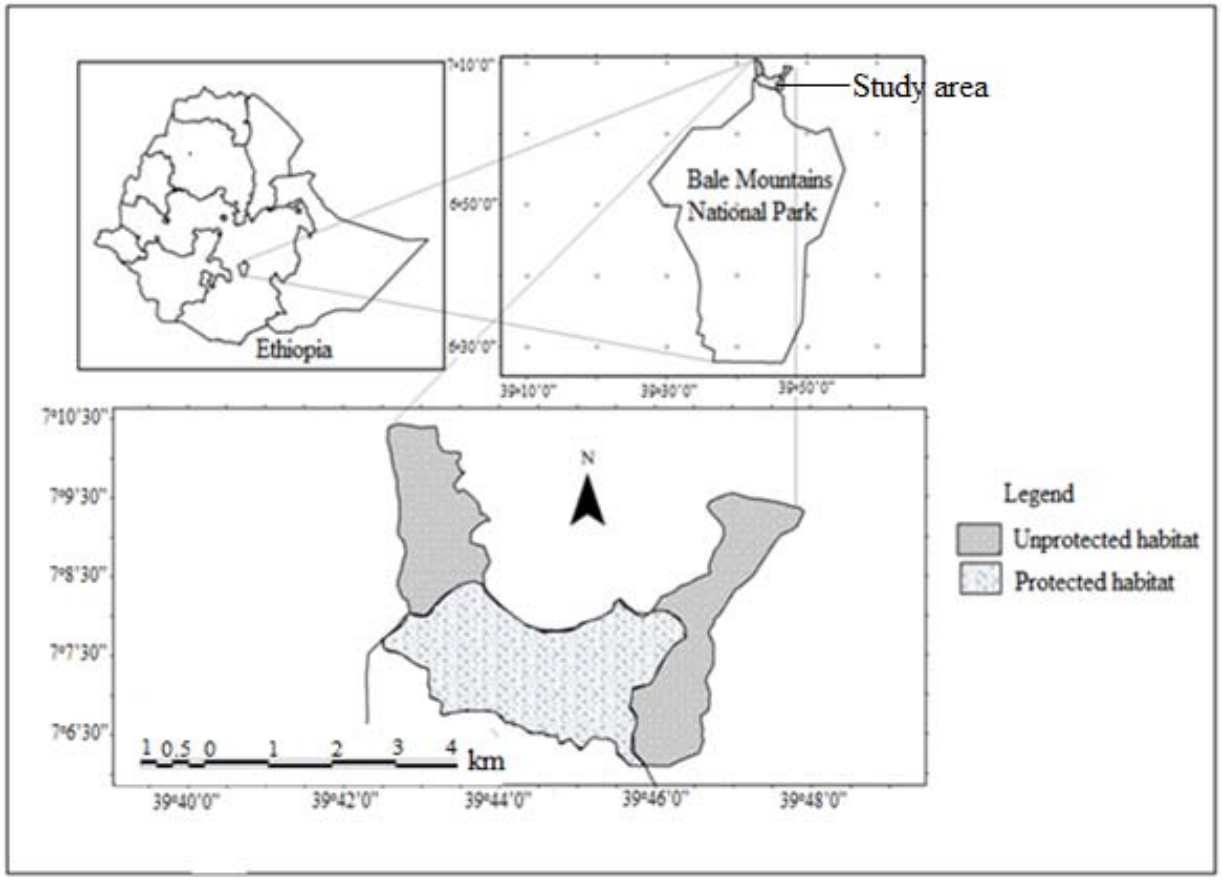

Figure 1. Location map of the study area.

This particular study was undertaken in the northern montane grasslands of the Bale Mountains, which is known as Gayssay valley. This grassland is situated between two mountain ranges as a central broad flat valley between altitudes of 3000 to 3150 masl (Fig. 1; for detail see also Hillman, 1986). The vegetation of the Gayssay valley is dominated by shrub species of *Artemisia afra and Helichrysum splendidum at relatively elevated areas, while Ferula* and *Kniphofia* (OARDB, 2007). The study area was classified into protected and unprotected montane grassland ecosystems based on the degree of disturbance and protection from the Park management. The protected grasslands fall inside the Bale Mountain National Park (BMNP), which was first proposed in the late 1960s to protect the afro alpine habitat and populations of the rare and endemic species of Mountain nyala (*Tragelaphus buxtoni*) and the Ethiopian wolf (*Canis simensis*) (Fishpool and Evans, 2001; OBARD, 2007).

Data collection and analysis

A preliminary survey was conducted during the first two weeks of August 2011. The physical features of the study area were assessed using ground survey. The coordinates of each study site were taken and their boundaries delineated. The study was conducted from August 2011 to March 2012, covering both wet and dry seasons.

The study area was classified into protected and unprotected montane grassland ecosystems based on the degree of disturbance and protection from the Park management. The total area of the protected (falling inside the BMNP) and unprotected habitats was 8.2 and 8.8 km^2, respectively. Random and stratified random sampling techniques were carried out to the protected and unprotected habitats, respectively (Bibby *et al.,* 1998). Eight transect lines of about one km long were reasonably spaced out at 250–300 m in each land use type to avoid double counting. Around 75% of each habitat area was covered for sampling. During bird counting standardized rate of movement at 2 km per hour for better detection and reduction in the disturbance of birds along the transect line (Bibby *et al*., 1992; Gregory and Gibbons, 1996; Bibby *et al.,* 1998). Data collection was carried out early in the morning from 6:30 to 10:30 a.m. and late in the afternoon from 2:30 to 6:00 p.m. replicating the same transects (Bibby *et al.,* 1992; Centerbury *et al.,* 2000).

Vegetation measurements such as grass , herb as well as shrub heights and covers were taken. This was carried out along the predetermined transect lines. Following Girma Mengesha *et al.* (2011), measurement was taken at 5×5 m quadrats established along each transect line at every 250 m.

Data on species richness between habitats were computed using Estimate S 8.20 (Colwell, 2006). The analysis was computed in a randomization with replacement of the species and sample. The overall bird species diversity and evenness was analyzed using Shannon-Weaver index of diversity. SPSS 17 software package and Excel descriptive statistical package were also used to analyze the relative abundance. Vegetation variables within and/or between habitats across seasons were compared using Chi-square tests. The relationships between bird species richness and vegetation variables were investigated using correlation analysis in SPSS.

RESULTS

A total of 72 avian species were identified during both seasons in the entire habitats. Among these Abyssinian long-claw (*Macronyx flavicollis*) and Spot-breasted lapwing (*Vanellus Melanocaphalus*) are endemic to Ethiopia. A total of 50 and 61 species were recorded in the protected and unprotected habitats, respectively. But, during the wet season, 64 bird species were recorded of which 47 were from the protected habitat and 53 were from the unprotected habitat. During the dry season, 54 species were recorded, of which 36 were observed in the protected habitat and 43 in the unprotected habitat (Table 1). From the total species recorded, 11 and 22 species were exclusively in the protected and unprotected habitats, respectively. In addition, 18 and 8 were recorded exclusively during the wet and dry seasons, respectively (Table 1).

During the wet season, higher avian diversity was recorded from the protected habitat 2.73 than the unprotected habitat 2.46. During the dry season, avian diversity in the protected and unprotected habitats was 1.22 and 2.07, respectively. The abundance of birds between two habitats during the wet (X^2= 110.09, df= 1 and $P<0.001$) and dry seasons (X^2= 638.4, df= 1 and $P < 0.001$) were significant.

Table 1. Avian species observed in both the protected and unprotected montane grassland.

Order	Family	Common Name	Scientific Name
Passeriformes	Turdidae	Mountain thrush	*Turdus abyssinicus*
		Groundscraper thrush	*Psophocichla litsitsirupa*
	Hirundinidae	Red-rumped swallow	*Hirundo daurica*
	Fringillidae	Streaky serin	*Serinus striolatus*
		Yellow-crowned canary[W]	*Serinus canicollis*
		Black-headed siskin	*Serinus nigriceps*
		African citril [W]	*Serinus citrinelloides*
		Brown-rumped seed-eater	*Serinus tristriatus*
	Passeridae	Grey-headed sparrow [WU]	*Passer griseus*
	Muscicapidae	Rueppell's robin-chat	*Cossypha semirufa*
		Common stonechat	*Saxicola torquata*
		Alpine chat	*Cercomela sodida*
		Isabelline wheatear	*Oenanthe isabelline*
		Pied wheatear [D]	*Oenanthe pleschanka*
	Cisticolidae	Black-backed cisticola	*Cisticola eximia*
		Ethiopian cisticola	*Cisticola lugubris*
		Sedge-warbler [P]	*Acrocephalus schoenobaenus*
	Nectariniidae	Tacazze sunbird [W]	*Nectarinia tacazze*
		Malachite sunbird [WP]	*Nectaria famosa*
	Estrildidae	Common waxbill [W]	*Estrilda astrild*
		Yellow-bellied waxbill [P]	*Esrilda melanotis*
	Viduidae	Pin-tailed whydah [WU]	*Vidua macroura*
	Motacillidae	Abyssinian longclaw[♣]	*Macronyx flavicollis*
		Mountain wagtail	*Motacilla clara*
		Yellow wagtail	*Motacilla flava*
		Tree pipit [P]	*Anthus trivilais*
		White wagtail [DU]	*Motacilla alba*
		Red-throated pipit [D]	*Anthus cevinus*
	Sturnidae	Grassveld pipit	*Anthus cinnamomeus*
		Grey wagtail [DU]	*Motacilla cinerea*
		Red-winged starling [WP]	*Onychognathus morio*
		Red-billed oxpecker	*Buphagus Erythrorhynchus*
		Greater blue-eared starling [WU]	*Lamprotornis Chalybaeus*
	Corvidae	Pied crow [WU]	*Corvus albus*
		African rook [U]	*Corvus capensis*
		Thick-billed raven [WP]	*Corvus crassirostris*
	Ploceidae	Baglafecht weaver	*Columba albitorques*
		Yellow bishop	*Euplectes capensis*
	Hirundinidae	Brown-throated martin	*Riparia paludicola*
	Alaudidae	Theckla lark	*Galerida theklae*
Psittaciformes	Psittacidae	Black-winged lovebird [WU]	*Agapornis taranta*
Columbiformes	Columbidae	Dusky turtle dove	*Streptopelia lugens*
		Speckled pigeon	*Columba guinea*
		White collared pigeon	*Coluba albitorques*
Charadriiformes	Scolopacidae	Marsh sandpiper [U]	*Tinga ochropus*
		Common sandpiper [U]	*Actitis hypoleucos*
		African snipe	*Gallinago nigripannis*
		Temmink's stint [DU]	*Calidris temminckii*
	Charadriidae	Spot-breasted lapwing [♣U]	*Vanellus Melanocaphalus*
		Three-banded plover [U]	*Charadrius tricollaris*
		Black-winged lapwing [U]	*Vanellus melanopterus*
Gruiformes	Rallidae	Rouget's rail	*Rougetius rougetii*
Galliformes	Phasianidae	Chestnut-naped francolin [P]	*Francolinus Castaneicellis*
		Moorland francolin [WP]	*Francolinus posilolaemus*
Falconiformes	Accipitridae	Tawny eagle [WP]	*Aquila rapax*
		Augur buzzard	*Buteo rufofuscus*
		Lappet-faced vulture [WU]	*Aegypius tracheliotos*
		Pallid harrier [P]	*Circus macrourus*
		Black-chested snake-eagle [WP]	*Circaetus pectoralis*
		Yellow-billed kite	*Milvus aegyptius*
		Black kite [U]	*Milvus migrans*
Anseriformes	Anatidae	Yellow-billed duck	*Anas undulate*
		African black duck	*Anas sparsa*
		Egyptian goose	*Alopochen aegyptiacus*
		Blue-winged goose	*Cyanochen cyanopterus*
Ciconiiformes	Threskiornithidae	Sacred ibis [U]	*Threskiornis aethiopica*
		Wattled ibis	*Bostrychia carunculate*
		Hadeda ibis [DU]	*Bostrychia hagedash*
	Ardeidae	Great white egret [WU]	*Egretta dimorpha*
		Little egret [WU]	*Egretta garzetta*
		Black-headed heron [U]	*Ardea melanocephala*
Coraciiformes	Upupidae	Eurasian hoopoe [DU]	*Upupa epops*

Note: (P=exclusively in protected habitat, U=exclusively in unprotected habitat, ♣=endemic to Ethiopia, W=wet season, D=dry season).

The EstimateS result shows that actual number of species actually observed in the protected habitat (48) almost nearly approaches the number of species expected to occur in the area (for example Sobs=42, ACE=49, ICE=50) (Table 2). This indicates that 84–86% of the species expected to be found in the protected habitat were discovered and the sample size taken in the area was satisfactory. The same is true for the unprotected habitat where the actual number of species found in the unprotected habitat was 61 and the estimated species number is almost the same (for example Sobs=58, ACE=65, ICE= 69), showing that 88–94% of the species were sampled (Table 3). Generally, similar to the comparison made based on the raw data, these result also shows that there was high species number in the unprotected habitat than protected habitat.

During the whole study period, most avian species were abundant 16 (41.03%) in the protected habitat and 23 (45.11%) in the unprotected habitat. However, there were uncommon bird species with six (15.38%) and six (7.84%) species to both protected and unprotected habitats, respectively.

Habitat measurement

In both habitats, mean grass height and cover, mean herb height and cover as well as mean shrub height and cover was higher during the wet season than the dry season (Table 4).

Table 2. Number of avian species in the protected habitat using EstimateS software.

Samples	Sobs (Mao Tau)	Uniques	Duplicates	ACE	ICE	Chao2	Jack2
1	23.88	24.00	0.00	302.44	267.63	135.64	0.00
2	31.07	15.44	16.24	46.63	54.44	33.97	39.40
3	35.80	14.42	7.70	45.17	51.52	41.25	49.25
4	39.33	14.18	7.26	47.06	52.70	44.12	54.78
5	41.98	13.28	8.40	48.68	53.12	45.27	56.54
6	43.93	11.76	10.52	50.01	43.27	45.94	55.92
7	45.25	9.36	13.34	50.13	52.26	46.26	52.20
8	42.00	6.00	16.00	48.81	49.90	46.16	45.46

Note: Prot. = Protected habitat, Unpro. = Unprotected habitat, ace=Abundance coverage-based species richness estimator, ice= Incidence coverage-based species richness estimator.

Table 3. Number of avian species in the unprotected habitat using EstimateS software.

Samples	Sobs (Mao Tau)	Uniques	Duplicates	ACE	ICE	Chao2	Jack2
1	27.37	27.08	5.89	396.68	350.47	350.47	0.00
2	37.32	20.12	5.60	60.40	74.58	48.03	47.46
3	43.51	19.16	5.32	57.64	66.76	57.68	61.19
4	47.94	17.90	4.55	58.27	65.48	60.63	66.87
5	51.35	16.60	4.36	60.11	65.79	62.86	69.81
6	54.07	15.74	4.06	62.03	66.74	63.87	71.56
7	56.25	14.70	3.25	63.42	67.34	63.89	72.15
8	58.00	14.00	0.00	65.11	68.55	64.12	73.03

Notations as in Table 2 above.

Table 4. Mean score of grass height and cover, herb height and cover and shrub height and cover in the protected and unprotected habitats during the wet and dry seasons.

Habitat	Mean grass height (cm)		Mean herb height (cm)		Mean shrub height (cm)		Mean grass cover (%)		Mean herb cover (%)		Mean shrub cover (%)	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Protected	175.83	104.1	62.9	3.63	92.9	74.84	264.78	201.72	95.94	14.54	106.38	69.88
Unprotected	6.032	1.74	6.71	0.81	1.42	0.00	65.74	52.05	44.28	5.27	2.38	0.00

There was a significant variation in grass height and cover between the protected and unprotected habitats during both seasons (X^2= 257.46, df= 1 and P < 0.001) and (X^2= 148.83, df= 1 and P < 0.001), respectively. Seasonally, there was a significant variation in the above two categories (height and cover) in the two habitats. In the protected habitat, there was significant variation in grass height and cover between wet and dry seasons (X^2= 18.38, df= 1 and P < 0.001) and (X^2= 8.44, df= 1 and P < 0.01), respectively.

Correlation of habitat measurements with avian richness and abundance

During the wet season, species richness of birds in the protected habitat was negatively correlated with grass height (R=-0.836), grass cover (R=-0.572) and positively correlated with herb height (R=0.423) and shrub cover (R=0.465). However, there was no correlation with herb cover (R=-0.126) and shrub height (R=0.119). During the dry season, bird species richness in the protected habitat was positively correlated with grass height (R=0.335), shrub height (R=0.386) and shrub cover (R=0.732) and negatively correlated with grass cover (R=-0.481) and herb height (R=-0.335). There was no correlation with herb cover (R= 0.293).

DISCUSSION

The montane grassland ecosystem of the BMNP hosts an array of birds, both resident and migratory. However, the protected habitat, which is relatively less disturbed (Hillman, 1986), was found to support smaller number of species as compared to the unprotected habitat. Several studies (*e.g.,* Girma Mengesha *et al.,* 2011; Gove *et al.,* 2011; Addisu Asefa, 2013) also found higher number of species in the disturbed habitat than in the undisturbed ones.

The difference of bird species preference is influenced by the individual species specific requirement to each specified habitat. Some species require habitats with short grasses and little cover and others require the reverse (Boren *et al.,* 1999. The presence of abundant macro-invertebrates in the ephemeral ponds of the unprotected habitat might have contributed for the presence of many species of wetland birds in the unprotected habitat. McIve and McInnis (2007) found large number of micro-invertebrates and birds associated with it in the grazed habitat exposed to livestock. This can potentially provide suitable food resource to some particular bird species guilds thus resulting to increased species richness.

Species diversity index and evenness was higher in the unprotected habitat than in the protected habitat during the entire study period even if habitat heterogeneity and vegetation structure was high in the protected habitat. Thus, it seems that the presence of abundant food resources, rather than habitat structural complexity, could be the major driving force shaping bird community structure in the area. The present result, however, contrasts with previous findings (*e.g.,* Thinh, 2006) that habitat heterogeneity and vegetation structures determine bird species diversity.

Seasonal variation in the temperature and rainfall in the study area was also observed (Hillman, 1986). As a result, there was a change in the volume of water in the streams and rivers crossing the Park. There was also a change in the amount of water collected in the ephemeral ponds during the dry season. Due to this, there might be a positive interaction between habitat and season in which during the wet season productivity of the habitats increase as well as the species richness. For instance, George *et al.* (1992) found a temperature related drought and great decline of birds in population and community structure (Oindo *et al.,* 2001; Kalkidan Esayas, 2010).

During the dry season, there was a significant variation in grass and herb height, herb cover as well as shrub height and cover in the unprotected and only herb height in the protected habitat. This change might have a profound effect in changing the bird species richness and abundance of these habitats between the wet and dry seasons. Boren *et al.* (1999) in their study revealed that change in vegetation cover was related to changes in the avian community composition by increasing prairie habitat associated species in low density rural population and generalist habitat associated species in the high density rural population landscapes.

Within a habitat, seasonal bird species similarity was higher in the protected habitat than in the unprotected habitat. This might be due to better habitat stability, which provides ample food resources and shelter in the protected habitat (Karr, 1976). Between the habitats, there was a variation in relative abundance of bird species (common, frequent, abundant and uncommon). This might be due to the difference in response to avian species to many habitat parameters such as vegetation.

The protected habitat was covered with tall grasses and shrub. This was difficult for wading birds to move through, find food and escape from

predators. But it is better and preferable for shy and cryptic birds such as *Francolinus spp.*, warbler species and others. Scheffers *et al.* (2006) also found that aerial and pond invertebrates were significantly more abundant at ephemeral ponds than at adjacent forest or shrub sites, providing one possible explanation for greater bird abundance at ephemeral ponds.

Grass, herb and shrub height and cover was higher in the protected habitat than the unprotected one. Birds respond to this habitat structure differently. For example, Chestnut-naped francolin (*Francolinus Castaneicellis)* and Moorland francolin (*Francolinus posilolaemus)* were positively associated with long grass and high cover. This difference might be due to the abundance of food resource and hiding place from their enemy in this habitat (Morris *et al.*, 2008; Jansen *et al.,* 2001).

In general, the result of this particular study shows that bird diversity, richness and abundance were not linearly associated with the vegetation measurements (such as grass height and cover, shrub height and cover and herb height and cover). This finding deviates from the findings of other studies (Karr and Roth, 1971; Popotnik and Giuliano, 2000) who reported that bird species diversity was linearly related to foliage height diversity and percent vegetation cover.

In the study area, livestock grazing is the most prominent threat to the habitats of the montane grassland ecosystem of BMNP. Such activities can have a profound impact on widespread population decline of many birds in a grassland habitat (Soderstro *et al.,* 2001). However, livestock grazing do not have the same effect to all bird species in one habitat birds respond to such pressures differently in a species specific fashion.

Further, expansion of farmlands in the grassland and logging of forest near the grassland area and expansion of settlements around the grassland habitat may affect avian species richness, abundance and distribution in the study area. Miller *et al.* (2003) also found that species richness declined as urbanization increased in the surrounding landscape in the lowland riparian areas of Colorado (USA). Brenna and Kuvlesk (2005) examined cumulative factors such as afforestation, in the eastern United States, fragmentation and replacement of prairie vegetation with agricultural landscape and large deterioration of western United State rangelands and found these to be the major causes for avian decline in these areas. However, human induced factors do not affect all avian species in one habitat rather it may sometimes favour other species. According to Miller *et al.* (2003), migrant and low nesting species were associated with lower levels of development in the habitat, whereas resident and cavity nesting species tended to increase with urbanization in a habitat.

CONCLUSION

The montane grassland ecosystem of the Bale Mountains National Park is the most important habitat for birds to nest, breed, shelter and feed as well as habitat for different animals. However, its species composition, diversity, abundance and distribution vary both seasonally and habitat wise. This can be associated with the individual species response to vegetation characteristics such as vegetation height, cover and feeding behaviour in addition to seasonality such as change in availability of moisture and temperature. Birds in this habitat also differ with reference to habitat characteristics

It is not only the protected part of the montane grassland, which has high avian diversity but also the area outside the Park supports numerous bird species regardless of human pressure from the surrounding area. Due to this, some important birds which are sensitive to human disturbance are becoming the prime victims of this disturbance.

In order to reduce all these things there should be balance between the wildlife and livestock grazing area with patches of ungrazed grassland and bush habitats in providing a mosaic of habitats that can support a diverse population of game birds. Moreover, community-based conservation should be carried out to implant the sense of ownership in the minds of the local people. Therefore, unless action is taken, these disturbance-sensitive bird species will suffer more on their survival.

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